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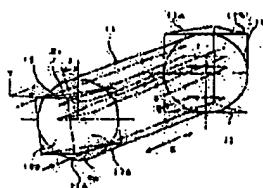
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### (54) MAGNETIC SENSOR



#### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a highly sensitive magnetic sensor using a single Faraday element.

**SOLUTION:** In this sensor, an optical path of light passing through the inside of the Faraday element 11 is changed inside both prisms using the prisms 12, 13 provided in a light-incident side end face 11A and a light-emitting side end face 11B of the Faraday element 11, and applied with reflection films in the respective end faces, plural times of going and returning transmission of the light are

repeated in the Faraday element 11 to make the optical paths parallel and separated each other along a magnetic field H, and the light is emitted from an emitting position R<sub>OUT</sub> different from an incident position R<sub>IN</sub> of the incident end face 11A. That is, the plural times of transmission of the light are repeated inside the Faraday element 11 along only the measuring magnetic field H not to be affected by other magnetic field and to provide highly sensitive detection result since element sensitivity is enhanced.

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## CLAIMS

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### [Claim(s)]

[Claim 1] The Faraday cell which changes the reinforcement of the light source which generates light, and the field which tends to be made to penetrate this light and it is going to detect into property change of the light which is the rotatory polarization angle of said light, It is the magnetometric sensor equipped with the light sensing portion which receives said light by which property conversion was carried out. With the incidence end-face side of the light of said Faraday cell, to the outgoing radiation end-face side of the light of an opposite hand It has the 1st optical means which carries out the multiple-times echo of the light by which outgoing radiation was carried out from said Faraday cell, and is returned to said Faraday cell. Said 1st optical means The magnetometric sensor characterized by reflecting said light so that the optical path of the reflected light in said Faraday cell may be almost parallel to the optical path of incident light and said both optical paths may dissociate.

[Claim 2] It is the magnetometric sensor which is equipped with the 2nd optical means which carries out the multiple-times echo of the light by which outgoing radiation was carried out to the incidence end-face side of light from the incidence end face of the light of said Faraday cell further in a magnetometric sensor according to claim 1, and is returned to said Faraday cell, and is characterized by reflecting said light so that said 2nd optical means may have the optical path of the reflected light in said Faraday cell almost parallel to the optical

path of incident light and said both optical paths may dissociate.

[Claim 3] The 1st optical means and the 2nd optical means are a magnetometric sensor characterized by being the prism with which the reflective film was given in the magnetometric sensor according to claim 1 or 2.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the magnetometric sensor using the phenomenon in which the plane of polarization of the advancing light rotates the inside of a Faraday cell according to the reinforcement of a field, and relates to the technique which raises the sensibility of this kind of magnetometric sensor especially.

[0002]

[Description of the Prior Art] Generally, the light by which incidence was carried out from the incidence end-face side of a Faraday cell penetrates a component, and outgoing radiation of the magnetometric sensor using the Faraday effect is carried out to an incidence side from the outgoing radiation end face of an

opposite hand. And the reinforcement of a field is detected change of the information on this outgoing radiation light, and by specifically getting to know the rotatory polarization angle of light. The sensibility of a component comes out enough to the reinforcement of a field to detect, and this component is made to penetrate light once in a certain case. However, since when element sensitivity is not enough obtains sufficient sensibility, drawing requires improvement in sensibility using the technique of lengthening the operation length of a component. For example, there is a thing which two or more components are arranged [ thing ] in a serial as the 1st technique, and makes light penetrate. [0003] Moreover, with the incidence end-face side of the light of a component, there are some which the reflective film is given [ some ] to the outgoing radiation end face of the light of an opposite hand, and carry out the reflective round trip of the light by the same optical path as the 2nd technique. The half mirror is used for separation of this incident light and outgoing radiation light.

[0004] Furthermore, the configuration and its actuation of the 3rd technique of making reflect light and raising sensibility are explained. As shown in drawing 6 , the object for the incidence of light and the prism for outgoing radiation are arranged to the ends of the upside side of the longitudinal direction of the component 30 of a rectangular parallelepiped, respectively. And the light by which was transmitted from optical fiber 10a and outgoing radiation was carried out through rod-lens 11a carries out incidence from the direction of slanting into a component 30 through prism 20a for incidence. The incident light of this slant reaches reflective film 31b which penetrated the inside of a component 30 and was given to the confrontation of the incidence side face of the light of a component 30. It reflects in the direction of slant by reflective film 31b, and this light goes to the incidence side face of light. Moreover, it reflects further and the light which reflective film 31a is also given to the side face by the side of the incidence of this light, and arrived at this side face goes to reflective film 31b of a confrontation. That is, repeating the reflective film 31a and 31b given to the both-sides side in the direction of slant, and repeating the echo of multiple times by

turns, light penetrates a component and outgoing radiation is carried out from prism 20b for outgoing radiation.

[0005]

[Problem(s) to be Solved by the Invention] However, in the case of the conventional example which has such a configuration, there are the following problems. There is a problem that the sensor itself becomes large, in the 1st technique of arranging [ technique ] two or more components in a serial, and making light penetrate. Moreover, since the component is expensive, it is not economical to use two or more components.

[0006] With the incidence end-face side of light, in the case of the 2nd technique of carrying out the both-way echo of the light on the same optical path using the component which gave the reflective film to the outgoing radiation end face of the light of an opposite hand, a half mirror etc. will be used for separation with incident light and outgoing radiation light, at the time of incidence and outgoing radiation, a part of light loses with this half mirror, and an SN ratio (Signal-to-Noise ratio) worsens. Moreover, since light passes along the same optical path in using coherent light for the light source, the effectiveness of interference poses a problem.

[0007] Moreover, there are the following troubles by the 3rd technique. Namely, as shown in drawing 7 , by the 3rd technique, light advances in the direction of slant to the measurement field H. Plane of polarization rotates the component L of the light of the measurement field H and this direction among rectangular cross 2 component L of light, and L' reflecting the strength of the measurement field H. On the other hand, plane of polarization rotates component L' of the light which intersects perpendicularly with the measurement field H reflecting the strength of field H' which intersects perpendicularly with the measurement field H. Consequently, the rotatory polarization of the light which penetrated the component 30 is influenced of field H' of not only the measurement field H but another direction, and has the problem that a detection error becomes large so much.

[0008] This invention is made in view of such a situation, and its detection sensitivity is high and, moreover, it aims at offering a magnetometric sensor with a small detection error.

[0009]

[Means for Solving the Problem] This invention takes the following configurations, in order to attain such an object. Namely, the Faraday cell which changes the reinforcement of the field which invention according to claim 1 tends to make penetrate the light source which generates light, and this light, and it is going to detect into property change of the light which is the rotatory polarization angle of said light, It is the magnetometric sensor equipped with the light sensing portion which receives said light by which property conversion was carried out. With the incidence end-face side of the light of said Faraday cell, to the outgoing radiation end-face side of the light of an opposite hand It has the 1st optical means which carries out the multiple-times echo of the light by which outgoing radiation was carried out from said Faraday cell, and is returned to said Faraday cell, said 1st optical means has the optical path of the reflected light in said Faraday cell almost parallel to the optical path of incident light, and said light is reflected so that said both optical paths may dissociate.

[0010] Invention according to claim 2 is equipped with the 2nd optical means which carries out the multiple-times echo of the light by which outgoing radiation was carried out to the incidence end-face side of light from the incidence end face of the light of said Faraday cell further in a magnetometric sensor according to claim 1, and is returned to said Faraday cell, said 2nd optical means has the optical path of the reflected light in said Faraday cell almost parallel to the optical path of incident light, and said light is reflected so that said both optical paths may dissociate.

[0011] In the magnetometric sensor according to claim 1 or 2, as for invention according to claim 3, the 1st optical means and the 2nd optical means are equipped with the given prism by the reflective film.

[0012]

[Function] The operation of this invention is as follows. That is, according to invention according to claim 1, the light which carried out incidence to the Faraday cell penetrates a Faraday cell in accordance with a field, and outgoing radiation is carried out to a plane-of-incidence side from the outgoing radiation end-face side of an opposite hand. This light by which outgoing radiation was carried out repeats a multiple-times echo in the 1st optical means installed in the outgoing radiation end face, and is returned into a Faraday cell. This returned light goes to an incidence end-face side. It dissociates and the optical path of the light which returns to this incidence end-face side is returned so that it is not parallel and may not interfere mostly with the optical path of incident light. Outgoing radiation of this light is carried out from a different location from the incidence location of plane of incidence.

[0013] According to invention according to claim 2, the 2nd optical means is further installed in the incidence end-face side of the light of a Faraday cell according to claim 1. Therefore, the light which penetrated the Faraday cell as mentioned above, reflected by the 1st optical means, was again returned to the Faraday cell, and went to the incidence end-face side repeats a multiple-times echo in the 2nd optical means which carried out outgoing radiation of the incidence end face, and was installed in the incidence end face, and is returned to a Faraday cell. This light is almost parallel to incident light and two optical paths of the point returned from the outgoing radiation end face, and it dissociates so that it may not interfere, and it goes to an outgoing radiation end face again. After repeating this the actuation of a series of two or more times and raising element sensitivity, outgoing radiation of the light is carried out from a different location from the incidence location of an incidence end face.

[0014] According to invention according to claim 3, an echo and optical-path design of light are easily carried out by using prism for the 1st optical means and the 2nd optical means.

[Embodiment of the Invention] Hereafter, one example of this invention is explained with reference to a drawing. First, drawing 1 is the perspective view

having shown the important section of one example of the magnetometric sensor concerning this invention.

[0015] The component section which is an important section of this example consists of Faraday cell 11 transformed to property change of light by making into rotatory polarization change of the MAG which is physical quantity, large-sized prism 12 arranged so that the light which carried out incidence to Faraday cell 11 may carry out multiple-times round trip transparency in accordance with a field in Faraday cell 11, and Faraday cell 11 may be inserted, and small prism 13. In addition, the prism 13 with the large-sized prism 12 small to the 1st optical means of this invention is equivalent to the 2nd optical means of this invention.

[0016] Faraday cell 11 is the configuration of the cylinder equipped with incidence end-face 11A of light, and outgoing radiation end-face 11B, and in order to earn element sensitivity, it is arranged so that incidence of the light may be carried out from one end-face 11A of the longitudinal direction of Faraday cell 11. For example, a diameter is [ 2mm and the die length of the size ] 5mm. In addition, this configuration may be a prism etc. Moreover, the yttrium iron garnet (Yttrium Iron Garnet) generally used is used for an ingredient.

[0017] The large-sized prism 12 is a rectangular prism with which the reflective film was given to end faces 12A and 12B, as the multiple-times echo of the light is carried out inside prism 12 and returned into Faraday cell 11. That is, this large-sized prism 12 carries out incidence of the light by which outgoing radiation was carried out by penetrating Faraday cell 11, and it repeats two right-angled echoes so that the character of KO may be drawn inside this prism 12. Moreover, this reflected reflected light is returned into Faraday cell 11, it is almost parallel to other optical paths, and it is constituted so that it may return to the incidence end-face 11A side again through the optical path separated so that it might not interfere. Moreover, the configuration of this prism 12 is designed by size which covers all outgoing radiation end-face 11B of Faraday cell 11. Moreover, since the prism 13 installed in incidence end-face 11A is performing adjustment and a design of light of a reflected light way, this prism 12 is placed in a fixed position

so that the shaft of top-most vertices may be parallel to the direction of medial-axis Y of Faraday cell 11.

[0018] The small prism 13 is a rectangular prism with which the reflective film was given to end faces 13A and 13B like said large-sized prism 12. That is, Incidence of the light to which this small prism 13 was also returned to Faraday cell 11 from said large-sized prism 12, and outgoing radiation was carried out from incidence end-face 11A is carried out, and two right-angled echoes are repeated so that the character of KO may be drawn inside. Moreover, this reflected light is constituted so that it may be again returned into Faraday cell 11 and may return to the end-face 11B side through the optical path which was almost parallel to other optical paths, and was separated so that it might not interfere. Moreover, the optical path which carried out the multiple-times transparency of the inside of Faraday cell 11 does not lap, but the location in which this small prism 13 is installed is set up so that it may become the location where the outgoing radiation location of light differed from the incidence location of incident light. That is, as shown in drawing 1 , in all incidence end-face 11A of the light of Faraday cell 11, there is nothing and prism 11 is constituted by size which opens every [ of the vertical Y shaft-orientations upper part of plane-of-incidence 11A, and the lower part / a part ] in segment-like area, alias a wrap, and further, to the direction of medial-axis Y of incidence end-face 11A of the light of Faraday cell 11, only an include angle theta is leaned and it is arranged.

[0019] In addition, whenever [ angle-of-inclination / of this prism 13 ], the light of theta which repeats multiple-times round trip transparency in Faraday cell 11 is mutually parallel, and it is set up so that it may pass along the optical path separated so that it might not interfere. Furthermore, in order to aim at improvement in the element sensitivity of Faraday cell 11, it is decided that sufficient operation length is secured. However, since light has the property that a beam diameter spreads as operation length becomes long, if it carries out the multiple-times round trip transparency of the inside of Faraday cell 11 and operation length is lengthened too much, the problem of a mutual optical path

interfering or overlapping will produce it. Therefore, it opts for operation length fully in consideration of this point.

[0020] Next, actuation of a round is explained. After the light irradiated from the light source which is not illustrated is changed into parallel light with a lens etc., it is sent to Faraday cell 11.

[0021] Incidence of this light is carried out from the incidence location RIN established in incidence end-face 11A of the light of Faraday cell 11. The light which carried out incidence penetrates the inside of Faraday cell 11 to Z shaft orientations in accordance with Field H.

[0022] Outgoing radiation of the transmitted light is carried out from other-end side 11B of Faraday cell 11, and it carries out incidence to the large-sized prism 12 installed in this end face 11. This light is reflected in X shaft orientations by the right angle by reflective film 12A of prism 12. If this reflected light reaches other end-face 12B which gave the reflective film of this prism 12, it will reflect in minus Z shaft orientations further at a right angle, and it will be returned into Faraday cell 11. That is, this light penetrates the inside of Faraday cell 11 toward incidence end-face 11A of light, meeting a passage and Field H in another optical path separated so that it might be parallel to the optical path of incident light and might not interfere in the inside of Faraday cell 11.

[0023] Incidence of the light which has penetrated the inside of said Faraday cell 11 is carried out to the small prism 13 which outgoing radiation was carried out from end-face 11A of Faraday cell 11, and was installed in end-face 11A. If this light that carried out incidence reaches reflective film 13A given to the end face of prism 13, it will be reflected in minus XY shaft orientations by this reflective film 13A at a right angle. If this reflected light reaches reflective film 13B of this prism 13, it will reflect in Z shaft orientations further at a right angle, and it will be returned into Faraday cell 11. Namely, this light is parallel to two optical paths of precedence mentioned above, and the inside of Faraday cell 11 is again penetrated toward outgoing radiation end-face 11B by dissociating so that it may not interfere, meeting Field H.

[0024] outgoing radiation location ROUT which the light which repeats a series of above-mentioned actuation, and which carries out and penetrates the inside of Faraday cell 11 shifted to minus Y shaft orientations little by little, and was eventually established in incidence end-face 11A of light from -- outgoing radiation is carried out.

[0025] In addition, as a result of operating the above-mentioned round, the scattered light may occur inside Faraday cell 11. In this case, as shown in drawing 2 , it is possible to separate only a light required of deciding the outgoing radiation optical path of light beforehand by the design stage, arranging the plate 14 which prepared pinhole 14A on the optical path of outgoing radiation light, and making that pinhole 14A pass outgoing radiation light. Moreover, it is also possible to take out outgoing radiation light in the various directions using a mirror etc.

[0026] In this example, detection of the physical quantity into which Faraday cell 11 was made to penetrate light and change of a field was changed by property change of light as a rotatory polarization angle of light detects only the rotatory polarization angle which carried out the multiple-times round trip transparency of the light which carried out incidence to Faraday cell 11 in accordance with Field H. That is, light is installed in the large-sized prism 12 installed in end-face 11B of Faraday cell 11 when carrying out the multiple-times round trip of the inside of Faraday cell 11, and end-face 11A, a right-angled echo is repeated inside the small prism 13, an optical-path change is made, and it is returned as a light in alignment with Field H into Faraday cell 11. Consequently, even if field H' which intersects perpendicularly with Field H exists, the noise component which had influenced by field H' like the 3rd technique of the conventional technique is removable. Furthermore, since it dissociates so that a mutual optical path may not interfere in the inside of single Faraday cell 11, and the multiple-times round trip transparency of the light is carried out, if element sensitivity is high and a high sensitivity detection result is obtained, it can \*\*.

[0027] Next, 4 pass methods with which light goes and comes back to the inside

of a Faraday cell twice are explained using drawing 3 . This example consists of large-sized prism 12 installed so that it might roughly divide and might put from the ends of the longitudinal direction of Faraday cell 11 and this Faraday cell 11, and small prism 13.

[0028] Faraday cells 11 are the configurations of incidence end-face 11A of light, and the cylinder equipped with outgoing radiation end-face 11B, and in order to earn element sensitivity, they are arranged so that incidence of the light may be carried out from one end-face 11A of the longitudinal direction of Faraday cell 11.

[0029] The large-sized prism 12 installed in end-face 11B of Faraday cell 11 is a rectangular prism with which the reflective film was given to end faces 12A and 12B. The configuration is the rectangular prism which had the four same sides as the diameter of Faraday cell 11, and carried out the configuration of the rectangular-head drill which is a square installation side.

[0030] The small prism 13 installed in end-face 11A of Faraday cell 11 is a rectangular prism with which the reflective film was given to end faces 13A and 13B like said large-sized prism 12. The configuration is the rectangular prism which carried out the configuration of a rectangular-head drill where the installation side to incidence end-face 11A of the light of Faraday cell 11 was a rectangle. That is, the longitudinal direction of the installation side of prism 13 is the same as the diameter of Faraday cell 12, and makes the direction of a short hand the same die length as a radius. This prism 13 is installed so that it may go from the incidence side of the light of Faraday cell 11 to illustrate and a right half may be covered from a center line Y-axis.

[0031] theta= 90 degrees of said prism 13 are leaned to the prism 12 installed in end-face 11B of Faraday cell 11, and it is installed in the condition. That is, the shaft of the top-most vertices of prism 13 is installed in X shaft orientations of Faraday cell 12 by parallel to the shaft of the top-most vertices of the prism 12 installed in end-face 11B of Faraday cell 11 being parallel to Y shaft orientations of Faraday cell 12.

[0032] Next, actuation of a round is explained. Although not illustrated, incidence

of the light into which the light from the light source was changed by parallel light with the lens is carried out from the incidence location RIN established in the upper left quadrant of end-face 11A of Faraday cell 11. This light that carried out incidence arrives at the location of the upper left quadrant of prism 12 from the travelling direction of the light which penetrates and illustrates the inside of Faraday cell 11 to Z shaft orientations in accordance with Field H.

[0033] This light that reached arrives at the location of the upper right quadrant of 12B which is the end face to which it was reflected in X shaft orientations by the right angle by end-face 12A to which the reflective film was given, and other reflective film of this prism 12 was given. It reflects in minus Z shaft orientations again by end-face 12B at a right angle, and this light is returned to Faraday cell 11. It dissociates so that it may not interfere, and it penetrates [ this returned light is parallel to incident light and ] the inside of Faraday cell 11, and arrives at the location of the upper part of prism 13.

[0034] It reflects in minus Y shaft orientations at a right angle by end-face 13A which gave the reflective film of prism 13, it is again reflected in Z shaft orientations by the right angle by end-face 13B to which other reflective film of this prism 13 was given, and this light that reached is returned into Faraday cell 11. This light is parallel to two optical paths of precedence, and it dissociates so that it may not interfere, and it penetrates the inside of Faraday cell 11.

[0035] This transmitted light reaches prism 12 again, and it is reflected in minus X shaft orientations by the right angle by end-face 12B to which the reflective film was given in the location of the lower right quadrant of this prism 12, and it arrives at the location of the lower left quadrant of end-face 12A in this prism 12. It is again reflected in minus Z shaft orientations by the right angle by end-face 12A to which the reflective film was given, and this light is returned into Faraday cell 11. outgoing radiation location ROUT of light of this light being parallel to three optical paths of precedence, and interfering in which it separated into be alike and the inside of Faraday cell 11 was established by transparency sushi and the lower left quadrant of incidence end-face 11A of light from -- outgoing

radiation is carried out.

[0036] Usually, a faraday's rotation angle is proportional to operation length. therefore, since the inside of Faraday cell 11 is penetrated 4 times in the case of this example, compared with \*\*\*\*\* , sensibility will improve the inside of Faraday cell 11 4 times once.

[0037] Next, one example of the magnetometric sensor using 4 pass methods is shown. As shown in drawing 4 , this example consists of the light source section 1 which roughly divides and generates light, the component section 10 changed into property change of light by making change of a field into rotatory polarization, and a light sensing portion 20 which receives the light by which outgoing radiation was carried out from the component section 10. Hereafter, each configuration is explained.

[0038] The light source section 1 consists of the light source 2 which generates light, and a polarizer 3 which changes and carries out outgoing radiation of this light to the linearly polarized light.

[0039] Moreover, the component section 10 consists of mirrors 14 for changing the prism 12 and 13 of Faraday cell 11 which incidence of said linearly polarized light is carried out [ Faraday cell ], and makes it penetrate, and two size which gave the reflective film to the end face in order to carry out the multiple-times echo of this straight-line light and to carry out the multiple-times round trip of the inside of a Faraday cell, and the direction of the reflected light by which outgoing radiation was carried out by carrying out the multiple-times round trip transparency of the inside of Faraday cell 11. Moreover, in order that a light sensing portion 20 may receive said light by which outgoing radiation was carried out, may investigate the existence or bearing of polarization and it may carry out a spectrum to each component The polarizer 21 (it is hereafter called a "analyzer".) which leaned 45 degrees and was installed to the linearly polarized light It consists of lenses 22a and 22b for condensing each of two polarization a and b by which the spectrum was carried out, and photodiodes 23a and 23b which are the photo-electric-translation means for receiving the each of

polarization which was condensed and changing into an electrical signal.

[0040] Next, actuation of a round is explained. By passing a polarizer 3, the light generated from the light source 2 is changed into straight-line light, and outgoing radiation is carried out towards Faraday cell 11.

[0041] Incidence of this straight-line light by which outgoing radiation was carried out is carried out from the part of the left-hand side in drawing 3 which is not covered by the prism 13 of Faraday cell 11. This light that carried out incidence penetrates the inside of Faraday cell 11 in accordance with Field H, a multiple-times echo is carried out, respectively by the reflective film of the prism 12 and 13 installed in the ends side of Faraday cell 11, and an optical-path change is made. That is, this light by which an optical-path change was made is returned into Faraday cell 11, in accordance with Field H, is mutually parallel and repeats transparency of 2 round trips through the optical path separated so that it might not interfere. Outgoing radiation of the light which repeated this transparency is carried out from the part of the right which is not covered by prism by the incidence end face of the light of Faraday cell 11. That is, this method is 4 pass methods which repeat four transparency for the inside of Faraday cell 11. An optical path is changed by the mirror 14 by which the light by which outgoing radiation was carried out was installed ahead [ outgoing radiation optical-path ].

[0042] Light is received with an analyzer 21 and the light by which an optical-path change was made can investigate the existence or bearing of polarization. As a result of being investigated, a spectrum is carried out to two components, the thing a with polarization, and the thing b without polarization, Polarization a is sent to lens 22a, and Polarization b is sent to lens 22b, respectively. The polarization components a and b are received with the photodiodes 23a and 23b which are photo-electric-translation means (FD), once it is condensed with Lenses 22a and 22b. Each quantity of light is changed into these received polarization components a and b by electrical signals A and B. Consequently, magnetic intensity is measured by the operation using the electrical signal of the changed polarization components A and B.

[0043] Said operation can obtain the detection result of (1) type to change of a field, if the adjoining electrical signals A and B detected by time series are used.  
 $(A-B)/(A+B)=\sin(2\theta)$  – (1)

Here, in minute Faraday rotation ( $2\theta \ll 1$ ), it can approximate with  $\sin(2\theta) \approx 2\theta$ , and (1) type becomes degree type (1)' and can obtain a linear detection result.

$(A-B)/(A+B)=2\theta$  – (1)' and this formula (1)' can be expressed like [ relation / of  $\theta=VHL$  of the Faraday effect ] a degree type (2). It can ask for magnetic-field-strength H from this (2) type.

$(A-B)/(A+B)=2VHL$  – (2)

Here, for  $\theta$ , a rotatory polarization angle and V are [ magnetic field strength and L of a Verdet's constant and H ] the die length of a Faraday cell. In this invention, in light, since transparency of multiple times is repeated in the single Faraday cell, the optical path length of light deserves said parameter L.

[0044] Deformation implementation of this invention can also be carried out not only in the above-mentioned example but as follows. (1) As shown in drawing 5, arrange the rectangular prism 12 which gave the reflective film 12A and 12B to the outgoing radiation side side of the light of an opposite hand with the end face by the side of the incidence of the light of Faraday cell 11. The light which carried out incidence penetrates with a passage the optical path which met Field H in the inside of Faraday cell 11. A transmitted light repeats two right-angled echoes to the minus Y shaft orientations illustrated by the reflective film 12A and 12B of the prism 12 installed in the outgoing radiation end face, and minus X shaft orientations, and is returned into Faraday cell 11. This light is returned to a plane-of-incidence side through the optical path separated so that it might be parallel to incident light and might not interfere in the inside of Faraday cell 11, and outgoing radiation is carried out from a different location from the incidence location of incident light. This light by which outgoing radiation was carried out has an optical path changed by the mirror 13 beforehand installed by optical-path design, and is condensed with a lens 14. This condensed light is outputted to a

photodiode 15. When carrying out 1 \*\*\*\* of light in Faraday cell 11 with such a two pass method, reservation of an optical path and separation of light are easier than the technique of carrying out the multiple-times round trip transparency of the light.

[0045] In addition, a current value is indirectly detectable although magnetic reinforcement is directly detected in this example. For example, a Faraday cell can be arranged to parallel to the field generated when a current is passed on an electric wire, and a current value can be calculated from the reinforcement of the MAG detected at this time, and the distance from an electric wire to a Faraday cell.

[0046]

[Effect of the Invention] According to invention according to claim 1, the light which penetrated the inside of a Faraday cell along the direction of a field repeats a multiple-times echo in the optical means installed in the outgoing radiation end face of an opposite hand with the plane-of-incidence side, and is returned into a Faraday cell so that clearly from the above explanation. Without being almost parallel to the optical path of incident light, and interfering with incident light along the direction of a field, it dissociates and the light returned to this plane-of-incidence side is also returned. Furthermore, outgoing radiation of this light is carried out from a different location from an incidence location. Consequently, since all the optical paths in a Faraday cell meet in the direction of a field, the high sensitivity detection result which is not influenced by noise components other than a measurement field can be obtained. Moreover, since the multiple-times transparency of the light is carried out in the Faraday cell and the sensibility of a component is improved using the single Faraday cell, it is economical.

[0047] According to invention according to claim 2, by preparing an optical means also in the incidence end face of light, it is returned from the outgoing radiation end face of an opposite hand, and the light which carried out incidence to the Faraday cell can repeat an echo in the optical means by the side of plane

of incidence further, and can return into a Faraday cell with a plane-of-incidence side. The inside of a Faraday cell is penetrated by the optical path separated so that it was not parallel and might not interfere in two or more light at this time mutually. By repeating actuation of this round, the multiple-times round trip transparency of the light can be carried out in a Faraday cell, and the optical path length can be earned. That is, element sensitivity can be raised further. Moreover, since the incidence location and outgoing radiation location of light differ from each other, a half mirror etc. can be used, it is not necessary to separate light, and the shift to the following process can be performed easily.

[0048] According to invention according to claim 3, an optical-path change can be easily made by using prism for an optical means on the outside of a Faraday cell.

[0049]

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[Translation done.]

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the perspective view having shown the component section of one example of the magnetometric sensor concerning this invention.

[Drawing 2] It is the sectional view of a pinhole plate prepared on the outgoing radiation optical path of light.

[Drawing 3] It is the perspective view of the component section using 4 pass methods of light.

[Drawing 4] It is the block diagram of the magnetometric sensor using 4 pass methods.

[Drawing 5] It is the block diagram of the two pass method of a modification.

[Drawing 6] It is the perspective view of the conventional example.

[Drawing 7] It is drawing having shown the optical path and field of light which penetrate the inside of the component of the conventional example.

**[Description of Notations]**

11 -- Faraday Cell

12 -- Large-sized Prism

12A -- End face of prism which gave the reflective film

12B -- End face of prism which gave the reflective film

13 -- Small Prism

13A -- End face of prism which gave the reflective film

13B -- End face of prism which gave the reflective film

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[Translation done.]

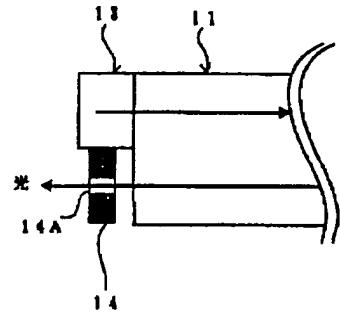
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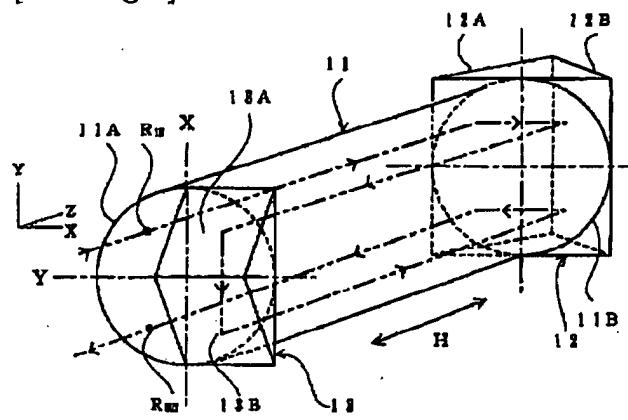
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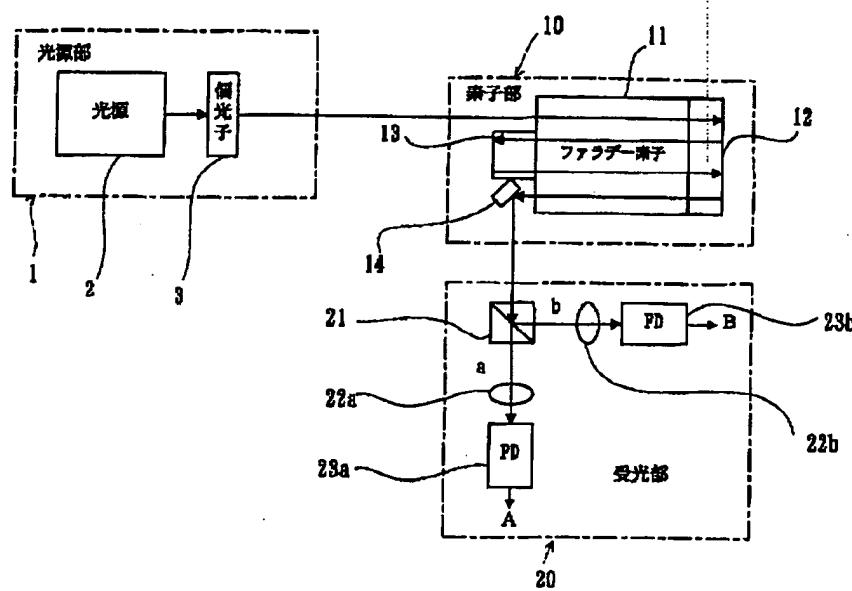
[Drawing 2]



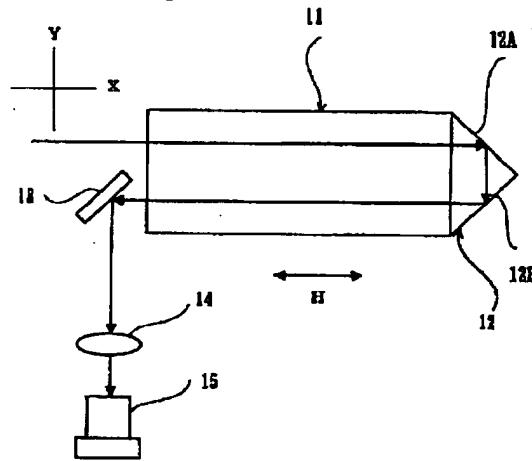
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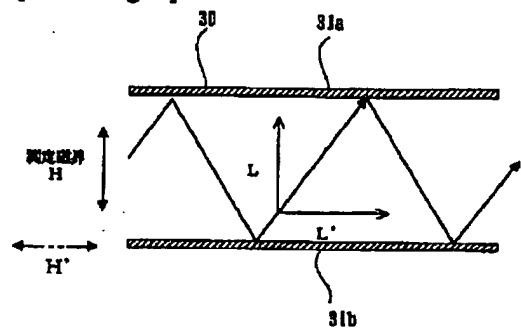
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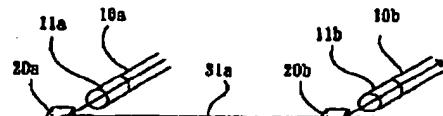
[Drawing 5]



[Drawing 6]

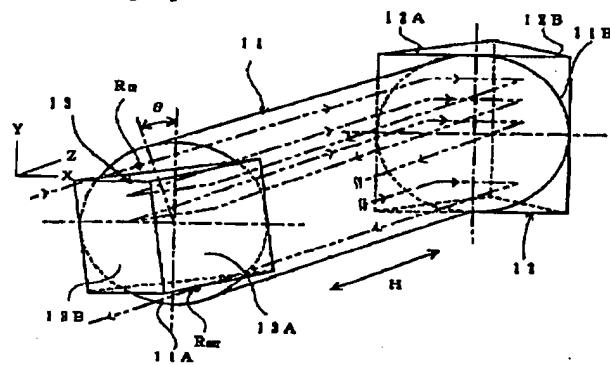


[Drawing 7]

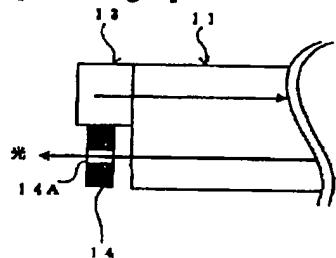


## DRAWINGS

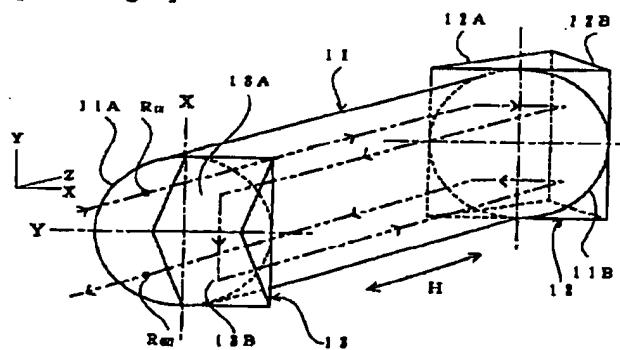
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Drawing 4]

(19) 日本国特許庁 (JP)

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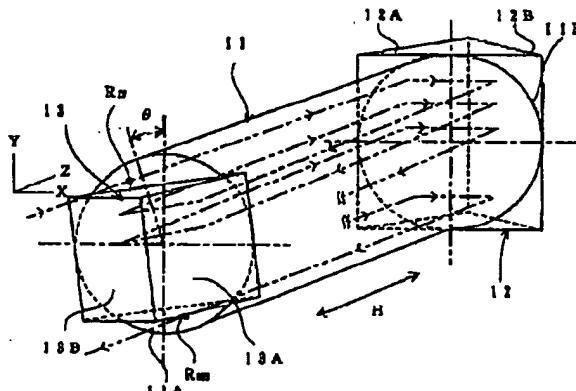
弁理士 杉谷 勉

F ターム(参考) 20017 MM01 AD12

(54) 【発明の名称】 磁気センサ

(57) 【要約】

【課題】 単一のファラデー素子を用いた高感度な磁気センサを供給する。

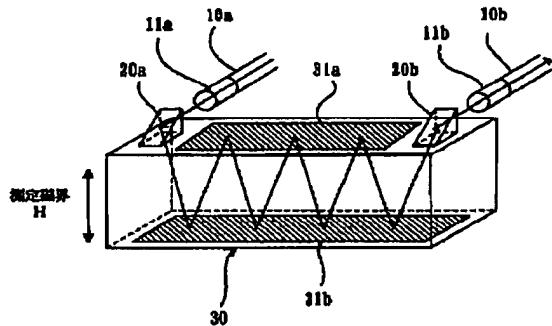
【解決手段】 この発明の磁気センサは、単一のファラデー素子11の光の入射側の端面11Aと、出射端面11Bに設置した端面に反射膜が施されプリズム12、13を用いてファラデー素子11中を透過してきた光の光路変更を両プリズム内部で行い、ファラデー素子11中には磁界Hに沿って互いの光路がほぼ平行、かつ分離されて複数回の光の往復透過が繰り返され、この光は入射端面11Aの入射位置R<sub>IN</sub>とは異なった出射位置R<sub>OUT</sub>から出射される。すなわち、光は測定磁界Hのみに沿ってファラデー素子11中を複数回の透過を繰り返すので、他の磁界による影響を受けず、かつ素子感度が向上されているので高感度な検出結果が得られる。

(2) 001-208818 (P 2001-208818A)

## 【特許請求の範囲】

【請求項1】 光を発生する光源と、この光を透過させて、検出しようとする磁界の強度を前記光の偏光面の回

置している。そして、光ファイバ10aから伝送されてロッドレンズ11aを通して出射された光が、入射用のアリズム20aを通して素子30内に斜めの方向から入



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[Translation done.]

(3) 001-208818 (P2001-208818A)

アラデー素子から出射された光を複数回反射して前記アラデー素子に戻す第1光学手段を備え、前記第1光学手段は、前記アラデー素子中の反射光の光路が入射光の光路とほぼ平行で、かつ前記両光路が分離するように前記光を反射する。

【0010】請求項2に記載の発明は、請求項1に記載の磁気センサにおいて、さらに光の入射端面側に、前記アラデー素子の光の入射端面から出射された光を複数回反射して前記アラデー素子に戻す第2光学手段を備え、前記第2光学手段は、前記アラデー素子中の反射光の光路が入射光の光路とほぼ平行で、かつ前記両光路が分離するように前記光を反射する。

【0011】請求項3に記載の発明は、請求項1または請求項2に記載の磁気センサにおいて、第1光学手段および第2光学手段は、反射膜が施されたプリズムを備えている。

【0012】

【作用】この発明の作用は次のとおりである。すなわち、請求項1に記載の発明によれば、アラデー素子に入射した光が、アラデー素子を磁界に沿って透過し、入射面側とは反対側の出射端面側から出射される。この出射された光は、出射端面に設置された第1光学手段中で複数回反射を繰り返してアラデー素子中に戻される。この戻された光は、入射端面側に向かう。この入射端面側に戻る光の光路は、入射光の光路とほぼ平行、かつ干渉することのないように分離されて戻される。この光は、入射面の入射位置とは異なった位置から出射される。

【0013】請求項2に記載の発明によれば、請求項1に記載のアラデー素子の光の入射端面側に、さらに第2光学手段を設置している。そのため、上述のようにアラデー素子を透過して第1光学手段により反射して再度アラデー素子に戻されて入射端面側に向かった光は、入射端面を出射して入射端面に設置された第2光学手段中で複数回反射を繰り返しアラデー素子に戻される。この光は、入射光と出射端面から戻された先の2光路とほぼ平行で、かつ干渉することのないように分離されて再び出射端面へ向かう。この一連の動作を複数回繰り返して素子感度を向上させた後に、光は入射端面の入射位置とは異なった位置から出射される。

【0014】請求項3に記載の発明によれば、第1光学手段および第2光学手段にプリズムを用いることで光の反射と光路設計が容易に実施される。

【発明の実施の形態】以下、図面を参照してこの発明の一実施例を説明する。まず、図1は、この発明に係る磁気センサの一実施例の要部を示した斜視図である。

【0015】本実施例の要部である素子部は、物理量である磁気の変化を偏光面の回転として光の特性変化に変換させるアラデー素子11と、アラデー素子11に入射した光が、アラデー素子11中で磁界に沿って複

数回往復透過するように、アラデー素子11を挟むように配置した大型のプリズム12と小型のプリズム13とともに構成されている。なお、大型のプリズム12はこの発明の第1光学手段に、小型のプリズム13はこの発明の第2光学手段に相当するものである。

【0016】アラデー素子11は、光の入射端面11Aと、出射端面11Bとを備えた円柱の形状であり、素子感度を稼ぐためにアラデー素子11の長手方向の一方の端面11Aから光を入射させるように配置されている。例えばそのサイズは、直径が2mm、長さが5mmである。なお、この形状は、角柱などであってもよい。また、材料には、一般的に使用されるイットリウム鉄ガーネット(Yttrium Iron Garnet)などが用いられる。

【0017】大型のプリズム12は、光をプリズム12の内部で複数回反射させてアラデー素子11中に戻すように、端面12Aと12Bに反射膜が施された直角プリズムである。すなわち、この大型のプリズム12は、アラデー素子11を透過して出射された光を入射して、このプリズム12の内部でコの字を描くように直角な2回の反射を繰り返す。また、この反射された反射光は、アラデー素子11中に戻されて他の光路とほぼ平行で、かつ干渉することのないように分離された光路を通って再度入射端面11A側に戻すように構成されている。また、このプリズム12の形状は、アラデー素子11の出射端面11Bを全て覆うようなサイズに設計されている。また、入射端面11Aに設置されたプリズム13で光の反射光路の調整および設計を行なっているので、このプリズム12は、アラデー素子11の中心軸Y方向に対して頂点の軸が平行になるように固定配置されている。

【0018】小型のプリズム13は、前記大型のプリズム12と同様に端面13Aと13Bに反射膜が施された直角プリズムである。すなわち、この小型のプリズム13も前記大型のプリズム12からアラデー素子11に戻されて入射端面11Aから出射された光を入射して、内部でコの字を描くように直角な2回の反射を繰り返す。また、この反射された光は、再びアラデー素子11中に戻されて他の光路とほぼ平行で、かつ干渉することのないように分離されてた光路を通って端面11B側に戻すように構成されている。また、この小型のプリズム13を設置する位置は、アラデー素子11中を複数回透過した光路が重ならず、光の出射位置と入射光の入射位置とが異なった位置になるように設定されている。すなわち、プリズム13は、図1に示すように、アラデー素子11の光の入射端面11Aを全て覆うことなく、入射面11Aの垂直Y軸方向上部および下部の一部づつを弓形状の面積で開放するようなサイズに構成され、さらにアラデー素子11の光の入射端面11Aの中心軸Y方向に対して角度θだけ傾けられて配置されている。

(4) 001-208818 (P2001-208818A)

【0019】なお、このアリズム13の傾き角度 $\theta$ は、ファラデー素子11中で複数回往復透過を繰り返す光が互いに平行で、かつ干渉することがないように分離された光路を通るように設定されている。さらに、ファラデー素子11の素子感度の向上を図るために、十分な作用長を確保するように決められている。しかしながら、光は、作用長が長くなるにつれてビーム径が広がる特性を有しているので、ファラデー素子11中を複数回往復透過させて作用長を長くしそうすると、互いの光路が干渉したり、重なり合うといった問題が生じる。よって、この点を十分に考慮して作用長が決められている。

【0020】次に、一巡の動作について説明する。図示しない光源から照射された光は、レンズなどにより平行光に変えられた後にファラデー素子11へ送られる。

【0021】この光は、ファラデー素子11の光の入射端面11Aに設けられた入射位置 $R_{in}$ から入射する。入射した光は、ファラデー素子11中を磁界Hに沿ってZ軸方向に透過する。

【0022】透過した光は、ファラデー素子11の他方の端面11Bから出射されて、この端面11に設置された大型のアリズム12に入射する。この光は、アリズム12の反射膜12AによりX軸方向に直角に反射される。この反射光は、同アリズム12の反射膜を施した他の端面12Bに到達すると、さらにマイナスZ軸方向に直角に反射してファラデー素子11中に戻される。すなわち、この光は、ファラデー素子11中を入射光の光路と平行で、かつ干渉することのないように分離された別の光路を通り、かつ磁界Hに沿いながら光の入射端面11Aに向かってファラデー素子11中を透過する。

【0023】前記ファラデー素子11中を透過してきた光は、ファラデー素子11の端面11Aから出射されて端面11Aに設置された小型のアリズム13に入射する。この入射した光は、アリズム13の端面に施された反射膜13Aに到達すると、この反射膜13AによりマイナスXY軸方向に直角に反射する。この反射した光は、同アリズム13の反射膜13Bに到達すると、さらにZ軸方向に直角に反射してファラデー素子11中に戻される。すなわち、この光は、上述した先行の2光路と平行で、かつ干渉することのないように分離されてファラデー素子11中を磁界Hに沿いながら、再度出射端面11Bに向かって透過する。

【0024】上述の一連の動作を繰り返してファラデー素子11中を透過する光は、少しずつマイナスY軸方向にずれてゆき、最終的に光の入射端面11Aに設けられた出射位置 $R_{out}$ から出射される。

【0025】なお、上述一巡の動作を行なった結果、ファラデー素子11の内部で散乱光が発生する場合もあり得る。この場合は、図2に示すように、光の出射光路を設計段階で予め決めておき、出射光の光路上にピンホール14Aを設けた板14を配置し、そのピンホール14

Aに出射光を通過させることで必要な光だけを分離することが可能である。また、出射光をミラーなどを用いてさまざまな方向に取り出すことも可能である。

【0026】この実施例において、光をファラデー素子11に透過させて磁界の変化を光の偏光面の回転角として光の特性変化に変換された物理量の検出は、ファラデー素子11に入射した光を磁界Hに沿って複数回往復透過させて偏光面の回転角のみを検出する。すなわち、光をファラデー素子11中を複数回往復させる際に、ファラデー素子11の端面11Bに設置した大型のアリズム12と、端面11Aに設置し小型のアリズム13の内部で直角な反射を繰り返して光路変更を行ない、ファラデー素子11中には磁界Hに沿った光として戻される。その結果、磁界Hと直交する磁界H'が存在していても、従来技術の第3の手法のように磁界H'によって影響していたノイズ成分を除去することができる。さらに、単一のファラデー素子11中を互いの光路が干渉することのないように分離して光を複数回往復透過させているので、素子感度が高く、高感度な検出結果を得ることができる。

【0027】次に光がファラデー素子中を2回往復する4バス方式について、図3を用いて説明する。この実施例は、大きく分けてファラデー素子11と、このファラデー素子11の長手方向の両端から挟み込むように設置された大型のアリズム12と、小型のアリズム13とから構成されている。

【0028】ファラデー素子11は、光の入射端面11Aと、出射端面11Bを備えた円柱の形状であり、素子感度を稼ぐためにファラデー素子11の長手方向の一方の端面11Aから光を入射させるように配置されている。

【0029】ファラデー素子11の端面11Bに設置された大型のアリズム12は、端面12A、12Bに反射膜が施された直角アリズムである。その形状は、ファラデー素子11の直径と同じ4辺を持ち、正方形な設置面である四角錐の形状をした直角アリズムである。

【0030】ファラデー素子11の端面11Aに設置された小型のアリズム13は、前記大型のアリズム12と同様に端面13A、13Bに反射膜が施された直角アリズムである。その形状は、ファラデー素子11の光の入射端面11Aへの設置面が長方形である四角錐の形状をした直角アリズムである。すなわち、アリズム13の設置面の長手方向がファラデー素子12の直径と同じであり、短手方向は半径と同じ長さとしている。このアリズム13は、図示するファラデー素子11の光の入射側から向かって中心線Y軸より右半分を覆うように設置されている。

【0031】前記アリズム13は、ファラデー素子11の端面11Bに設置されたアリズム12に対して $\theta = 90^\circ$ 傾けられ状態で設置されている。すなわち、ファラ

!((5) 001-208818 (P2001-208818A)

テー素子1 1の端面1 1 Bに設置されたプリズム1 2の頂点の軸が、ファラデー素子1 2のY軸方向に平行であるのに対し、アリズム1 3の頂点の軸はファラデー素子1 2のX軸方向に平行に設置されている。

【0032】次に、一巡の動作について説明する。図示しないが、光源からの光をレンズで平行光に変えられた光は、ファラデー素子1 1の端面1 1 Aの左上4分の1に設けられた入射位置R<sub>IN</sub>から入射する。この入射した光は、ファラデー素子1 1中を磁界Hに沿ってZ軸方向に透過し、図示する光の進行方向よりプリズム1 2の左上4分の1の位置に到達する。

【0033】この到達した光は、反射膜が施された端面1 2 AによりX軸方向に直角に反射されて同プリズム1 2の他の反射膜の施された端面である1 2 Bの右上4分の1の位置に到達する。この光は、端面1 2 BでマイナスZ軸方向に再度直角に反射してファラデー素子1 1に戻される。この戻された光は、入射光と平行で、かつ干渉することのないように分離されてファラデー素子1 1中を透過し、アリズム1 3の上部の位置に到達する。

【0034】この到達した光は、プリズム1 3の反射膜を施した端面1 3 AによりマイナスY軸方向に直角に反射し、同プリズム1 3の他の反射膜の施された端面1 3 BでZ軸方向に再度直角に反射されてファラデー素子1 1中に戻される。この光は、先行の2光路と平行で、かつ干渉することのないように分離されてファラデー素子1 1中を透過する。

【0035】この透過した光は、再度プリズム1 2に到達し、このプリズム1 2の右下4分の1の位置で反射膜の施された端面1 2 BによりマイナスX軸方向に直角に反射されて同プリズム1 2内の端面1 2 Aの左下4分の1の位置に到達する。この光は、反射膜の施された端面1 2 AによりマイナスZ軸方向に再度直角に反射されてファラデー素子1 1中に戻される。この光は、先行の3光路と平行で、かつ干渉することのないように分離されてファラデー素子1 1中を透過すし、光の入射端面1 1 Aの左下4分の1に設けられた光の出射位置R<sub>OUT</sub>から出射される。

【0036】通常、ファラデー回転角は作用長に比例する。そのため、この実施例の場合は、ファラデー素子1 1中を4回透過しているので、ファラデー素子1 1中を1回透過すものに比べ感度が4倍向上することになる。

【0037】次に4バス方式を用いた磁気センサの一実施例を示す。図4に示すようにこの実施例は、大きく分けて光を発生する光源部1と、磁界の変化を偏光面の回転として光の特性変化に変換する素子部10と、素子部10から出射された光を受光する受光部20とから構成されている。以下、それぞれの構成について説明する。

【0038】光源部1は、光を発生する光源2と、この光を直線偏光に変えて出射する偏光子3とから構成され

ている。

【0039】また、素子部10は、前記直線偏光を入射して透過させるファラデー素子1 1と、この直線光を複数回反射させてファラデー素子中を複数回往復させるために、端面に反射膜を施した大小2つのプリズム1 2、1 3と、ファラデー素子1 1中を複数回往復透過して出射された反射光の方向を変えるためのミラー1 4とから構成されている。また、受光部20は、前記出射された光を受光して偏光の有無もしくは方位を調べて各成分に分光するために、直線偏光に対して45度傾けて設置された偏光子2 1(以下、「検光子」という。)と、分光された2つの偏光a、bのそれぞれを集光するためのレンズ2 2 a、2 2 bと、その集光された偏光のそれぞれを受光して電気信号に変換するための光電変換手段であるフォトダイオード2 3 a、2 3 bとから構成されている。

【0040】次に一巡の動作について説明する。光源2から発生された光は、偏光子3を通過することにより直線光に変換されてファラデー素子1 1に向けて出射される。

【0041】この出射された直線光は、ファラデー素子1 1のプリズム1 3で覆われていない図3における左側の部分から入射する。この入射した光は、ファラデー素子1 1中を磁界Hに沿って透過し、ファラデー素子1 1の両端面に設置されたプリズム1 2、1 3の反射膜でそれぞれ複数回反射されて光路変更がされる。すなわち、この光路変更された光は、ファラデー素子1 1中に戻されて磁界Hに沿って互いに平行で、かつ干渉しないように分離された光路を通り2往復の透過を繰り返す。この透過を繰り返した光は、ファラデー素子1 1の光の入射端面でプリズムにより覆われていない右の部分から出射される。すなわち、この方式は、ファラデー素子1 1中を4回の透過を繰り返す4バス方式である。出射された光は、出射光路前方に設置されたミラー1 4により光路の変更される。

【0042】光路変更された光は、検光子2 1で受光されて偏光の有無もしくは方位を調べられる。調べられた結果、偏光の有るものaと、偏光の無いものbの2つの成分に分光して、偏光aをレンズ2 2 aに、偏光bをレンズ2 2 bにそれぞれ送る。偏光成分a、bはレンズ2 2 a、2 2 bで一旦集光された後に光電変換手段(FD)であるフォトダイオード2 3 a、2 3 bで受光される。この受光された偏光成分a、bは、それぞれの光量を電気信号A、Bに変換される。その結果、変換された偏光成分A、Bの電気信号を用いて、演算により磁気強度を計測する。

【0043】前記演算は、時系列に検出された隣接する電気信号A、Bを用いると、磁界の変化に対し(1)式の検出結果を得ることができる。

$$(A-B)/(A+B) = \sin(2\theta) \quad \dots \quad (1)$$

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ここで、微小なファラデー回転 ( $2\theta < 1$ )においては、 $\sin(2\theta) \approx 2\theta$  と近似でき、(1)式は次式

(1)'となりリニアな検出結果を得ることができる。

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#### 【特許請求の範囲】

【請求項1】 光を発生する光源と、この光を透過させて、検出しようとする磁界の強度を前記光の偏光面の回転角である光の特性変化に変換するファラデー素子と、前記特性変換された光を受光する受光部とを備えた磁気センサであって、前記ファラデー素子の光の入射端面側とは反対側の光の出射端面側に、前記ファラデー素子から出射された光を複数回反射して前記ファラデー素子に戻す第1光学手段を備え、前記第1光学手段は、前記ファラデー素子中の反射光の光路が入射光の光路とほぼ平行で、かつ前記両光路が分離するように前記光を反射することを特徴とする磁気センサ。

【請求項2】 請求項1に記載の磁気センサにおいて、さらに光の入射端面側に、前記ファラデー素子の光の入射端面から出射された光を複数回反射して前記ファラデー素子に戻す第2光学手段を備え、前記第2光学手段は、前記ファラデー素子中の反射光の光路が入射光の光路とほぼ平行で、かつ前記両光路が分離するように前記光を反射することを特徴とする磁気センサ。

【請求項3】 請求項1または請求項2に記載の磁気センサにおいて、第1光学手段および第2光学手段は、反射膜が施されたプリズムであることを特徴とする磁気センサ。

#### 【発明の詳細な説明】

##### 【0001】

【発明の属する技術分野】 この発明は、ファラデー素子中を進行する光の偏光面が磁界の強度に応じて回転する現象を利用した磁気センサに係り、特に、この種の磁気センサの感度を向上させる技術に関する。

##### 【0002】

【従来の技術】 一般に、ファラデー効果を利用した磁気センサは、ファラデー素子の入射端面側から入射された光が素子を透過して入射側とは反対側の出射端面から出射される。そして、この出射光の情報の変化、具体的には光の偏光面の回転角を知ることにより磁界の強度を検出している。検出したい磁界の強度に対して素子の感度が十分である場合には、この素子に光を一回透過させている。しかし、素子感度が十分でない場合は、十分な感度を得るために、素子の作用長を長くする手法を用いて感度の向上を図っている。例えば、第1の手法として、複数個の素子を直列に並べて光を透過させるものがある。

【0003】 また、第2の手法として、素子の光の入射端面側とは反対側の光の出射端面に反射膜を施して同一光路で光を反射往復させるものがある。この入射光と出射光の分離には、ハーフミラーを用いている。

【0004】 さらに、光を反射させて感度を上げる第3の手法の構成およびその動作について説明する。図6に示すように、直方体の素子30の長手方向の上側面の両端に、光の入射用および出射用のプリズムをそれぞれ配

置している。そして、光ファイバ10aから伝送されてロッドレンズ11aを通して出射された光が、入射用のプリズム20aを通して素子30内に斜めの方向から入射する。この斜めの入射光が、素子30中を透過して素子30の光の入射側面の対面に施された反射膜31bに到達する。この光は、反射膜31bで斜め方向に反射して光の入射側面へ向かう。また、この光の入射側の側面にも反射膜31aが施されており、この側面に到達した光は、さらに反射して対面の反射膜31bへ向かう。すなわち、光は、両側面に施された反射膜31a、31bを斜め方向に交互に複数回の反射を繰り返しながら素子を透過して出射用のプリズム20bから出射される。

##### 【0005】

【発明が解決しようとする課題】 しかしながら、このような構成を有する従来例の場合には、次のような問題がある。複数個の素子を直列に並べて光を透過させる第1の手法においては、センサ自体が大きくなるという問題がある。また、素子が高価であるので複数個の素子を使うことは経済的ではない。

【0006】 光の入射端面側とは反対側の光の出射端面に反射膜を施した素子を用いて光を同一光路上で往復反射させる第2の手法の場合は、入射光と出射光との分離にハーフミラーなどを用いることとなり、入射時および出射時に、光の一部がこのハーフミラーにより損失してS/N比 (Signal-to-Noise ratio) が悪くなる。また、光源にコヒーレント光を用いる場合には、光が同一光路を通るので、干渉の効果が問題となる。

【0007】 また、第3の手法では次のような問題点がある。すなわち、図7に示すように第3の手法では、測定磁界Hに対して光が斜め方向に進行する。光の直交L成分L、L'のうち、測定磁界Hと同方向の光の成分Lは測定磁界Hの強さを反映して偏光面が回転する。一方、測定磁界Hと直交する光の成分L'は、測定磁界Hと直交する磁界H'の強さを反映して偏光面が回転する。その結果、素子30を透過した光の偏光面の回転は、測定磁界Hだけではなく別方向の磁界H'の影響を受け、それだけ検出誤差が大きくなるという問題がある。

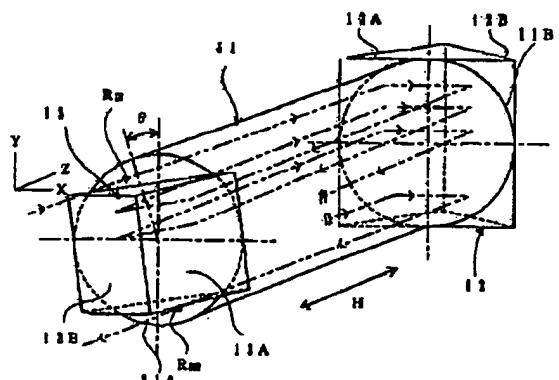
【0008】 この発明は、このような事情に鑑みてなされたものであって、検出感度が高く、しかも検出誤差が小さい磁気センサを提供することを目的とする。

##### 【0009】

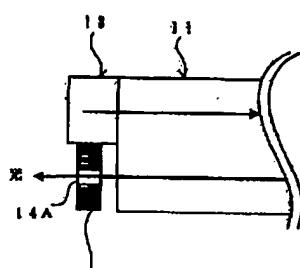
【課題を解決するための手段】 この発明は、このような目的を達成するために、次のような構成をとる。すなわち、請求項1に記載の発明は、光を発生する光源と、この光を透過させて、検出しようとする磁界の強度を前記光の偏光面の回転角である光の特性変化に変換するファラデー素子と、前記特性変換された光を受光する受光部とを備えた磁気センサであって、前記ファラデー素子の光の入射端面側とは反対側の光の出射端面側に、前記フ

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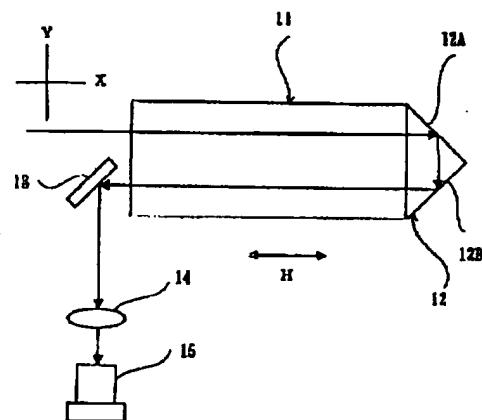
【図1】



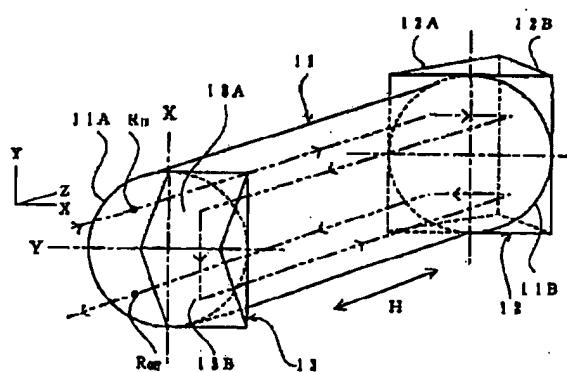
【図2】



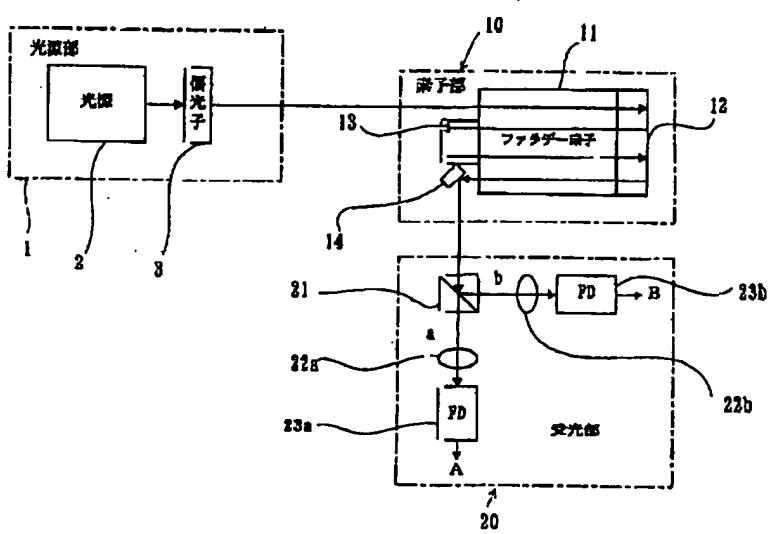
【図5】



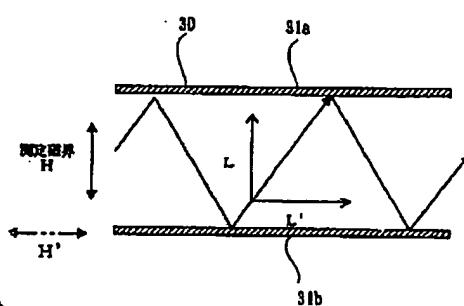
【図3】



【図4】



【図7】



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【図6】

